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DIFERENCES BETWEEN RECALCULATED AND ORIGINAL DOBSON TOTAL OZONE DATA FROM HRADEC KRALOVE, CZECHOSLOVAKIA, 1962-1990.

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ABSTRACT

Backward re-evaluation of long-term total ozone measurements from the Solar and Ozone Observatory of Czech Hydrometeorological Institute at Hradec Kralove, Czechoslovakia, was performed for the period 1962-1990. The homogenization was carried out with respect to the calibration level of the World Primary Standard Spectrophotometer No.83 - WPSS by means of day-by-day recalculations of more than 25000 individual measurements using the R-N Tables reconstructed after international comparisons and regular standard lamp tests of the Dobson spectrophotometer No.74. The results showed significant differences among the recalculated data and those original ones published in the bulletins Ozone Data for the World. In the period 1962-1979 they reached 10-19 D.U. (3.0-5.5%) for annual averages and even 26 D.U. (7.0%) for monthly averages of total ozone. Such differences exceed several times accuracy of measuring and can significantly influence character of trends of total ozone in Central Europe. The refore the results from Hradec Kralove support the calls for re-evaluation of all historical Dobson total ozone data sets at individual stations of Global Ozone Observing System.

1. INTRODUCTION

Long-term ground-based measurements of total ozone in the Global Ozone Observing System (GOOS) of the World Meteorological Organization (WMO) enabled creation of the data sets which are important sources of information for monitoring and analyses of the ozone layer. Nevertheless, their reliable use requires above all individual homogenization so as the data series are comparable with one another. This is one of the most important conclusions, declared in the Report of the International Ozone Trends Panel 1988 [Bojkov,1988], and recommendations of WMO.

Establishment of the Dobson spectrophotometer No.83 as a World Primary Standard Spectrophotometer (WPSS) [Komhyr et al., 1989b] and realization of international comparisons of the spectrophotometers gave a possibility to the individual measuring stations to specify relations of their instruments towards the WPSS's calibration level and to do day-by-day backward recalculations of their data sets. Some basic information and results of such homogenization of the total ozone data at the Solar and Ozone Observatory of the Czech Hydrometeorological Institute in Hradec Kralove, Czechoslovakia, are given in this contribution.

2. MEASUREMENTS OF TOTAL OZONE AT HRADEC KRALOVE

Measurements of total ozone have been performed at Hradec Kralove since August 1961, when the Observatory was incorporated into GOOS, station No.96 [WMO-WODC]. The ozone data from Hradec Kralove are regularly submitted to the World Ozone Data Center (WODC) at Toronto from the very beginning of the measuring. They are published in the bimonthly bulletins Ozone Data for the World and frequently used by scientists in various studies concerning total ozone.

Measurements of total ozone are carried out at Hradec Kralove with the Dobson spectrophotometer No.74 which is maintained with respect to the internationally adopted regulations and recommendations [Dobson,1957a,1957b,1962, Komhyr,1980]. The Direct Sun Ground Quartz Plate (DSGQP), Zenith Blue (ZB) and Zenith Cloudy (ZC) observations are performed on the wavelength pairs AD,CD and CC'.

The spectrophotometer No.74 was renovated and adjusted by the specialists from NOAA at Potsdam, Germany in 1979. In 1986 the instrument was compared side-by-side with the WPSS No.83 at Arosa, Switzerland. Stability of its calibration level was checked at the international comparison at Arosa in 1990 including calibration of absorption wedges and processing of new G-Tables. Comparisons of the spectrophotometer No.74 with WPSS and substandard No.65 (USA) at Arosa showed the differences of total ozone for various values of MU that did not exceed 0.35% and that confirmed its fairly good MU-dependence [Komhyr et. al.,1989a,Komhyr 1990]. Since 1962 the instrument has been tested regularly while using the standard lamps 74-B, QJ-74-1,QJ-74-2 and the mercury lamp [Dobson,1957]. The results of international comparisons and standard lamp tests enabled homogenization of the total ozone data series from Hradec Kralove in the way described below.

3. METHODOLOGY OF HOMOGENIZATION

Creation of the total ozone data base at Hradec Kralove for the period 1962-1990 presented on the WPSS's calibration level and therefore being internationally comparable was the chief goal of homogenization. It was realized by means of backwards recalculations and complex assessment of all measurements of total ozone from the period under consideration. New R-N Tables of the spectrophotometer No.74 reconstructed for each year were applied in the data processing. The following principles were respected in recalculations.

- The R-N Tables were reconstructed on the basis of the results of the international comparisons at Potsdam 1979, Arosa 1986, Arosa 1990 and regular standard lamp tests as described by Komhyr [Komhyr,1980].

- The R-N Tables established at Arosa in 1986 after side-by-side comparison with WPSS were taken as a reference and modified for individual years by means of the correction factors given in Table 1.

- The absorption coefficients implemented by IAMAP in 1968 were used for the whole period of homogenization.

- Recalculations of DSGQP ozone values were made in the first step while the ZB and ZC ones in the end by means of correction factors established from parallel direct sun and zenith observations.

- The measurements made on the AD wavelength pair were taken as primary in the period from March to October while the CD wavelength pair was prefered in the winter period from November to February.

- The WPSS's calibration level accepted in 1986 was increased by 0.35 percent according to its shift declared at Arosa 1990 [Komhyr,1990].

More than 25000 individual measurements from the period 01. 01. 1962 - 31. 12. 1990 were recalculated in the course of homogenization and at least 60 percent of them were of Direct Sun type. In last twenty years total ozone was measured on more than 90 percent of days in a year at Hradec Kralove. After final check and assessment of the recalculated data altogether 22675 measurements were incorporated into the homogenized total ozone data base. These results were published together with detailed description of methodology of homogenization in the final report of the work [Vanicek,1991].

Table 1. Yearly averages of Standard Lamp readings and corrections of R-N Tables relative to 1986 values, Dobson spectrophotometer No.74, Hradec Kralove, 1962-1990.

		Standard Lamp Readings (°)				Corr. of R-N Tables		
YEAR		R_A	R_C	R_D	R_D-R_A	$corN_A$	$corN_C$	$corN_D$
1962	74-8 Standard Lamp	39.75	40.26	43.87	4.12	5.64	7.06	5.71
1963		39.70	40.23	44.06	4.36	5.69	7.09	5.52
1964		39.09	39.78	43.48	4.39	6.30	7.54	6.10
1965		39.19	40.16	43.92	4.73	6.20	7.16	5.66
1966		39.80	40.93	44.62	4.82	5.59	6.39	4.96
1967		41.23	42.54	46.18	4.95	4.16	4.78	3.40
1968		42.50	43.23	47.20	4.70	2.89	4.09	2.38
1969		41.87	43.44	46.85	4.98	3.52	3.88	2.73
1970		41.95	43.35	46.80	4.85	3.44	3.97	2.78
1971		41.80	43.30	46.60	4.80	3.59	4.02	2.98
1972		44.10	45.90	49.00	4.90	1.29	1.42	0.58
1973 x		39.90	41.80	43.84	3.94	5.49	5.52	5.74
1974		40.82	42.35	44.95	4.13	4.57	4.97	4.63
1975		42.25	43.50	46.15	3.90	3.14	3.82	3.43
1976		44.13	45.13	47.60	3.47	1.26	2.19	1.98
1977		44.75	45.70	48.00	3.25	0.64	1.62	1.58
1978		45.30	46.20	48.35	3.05	0.09	1.12	1.23
1979 xx		45.68	46.62	48.63	2.95	-0.29	0.70	0.95
1979 +		43.76	45.97	48.76				
1979 ++	QJ-74-1 Standard Lamp	26.66	31.76	37.13	10.47	1.63	1.35	0.82
1980		26.66	31.76	37.13	10.47	1.63	1.35	0.82
1981		26.99	32.01	37.25	10.26	1.30	1.10	0.70
1982		27.32	32.26	37.37	10.05	0.97	0.85	0.58
1983		27.64	32.50	37.50	9.86	0.65	0.61	0.45
1984		28.16	33.06	38.01	9.85	0.13	0.08	-0.06
1985		28.33	33.13	38.08	9.75	-0.04	-0.20	-0.13
1986 o		28.29	33.11	37.95	9.66	0.00	0.00	0.00
1987		28.36	33.33	38.03	9.67	-0.07	-0.22	-0.08
1988		28.59	33.48	38.08	9.49	-0.30	-0.37	-0.13
1989		29.14	34.00	38.53	9.39	-0.85	-0.89	-0.58
1990		28.70	33.65	38.16	9.46	-0.41	-0.54	-0.21

x Replacing of photomultiplier tube.
xx Values before readjustment of the instrument, valid till 7/79.
+ Values after readjustment of the instrument (Potsdam, 7/79).
++ Extended 1980 values, valid since 7/79.
o Reference values for corrections of R-N Tables.

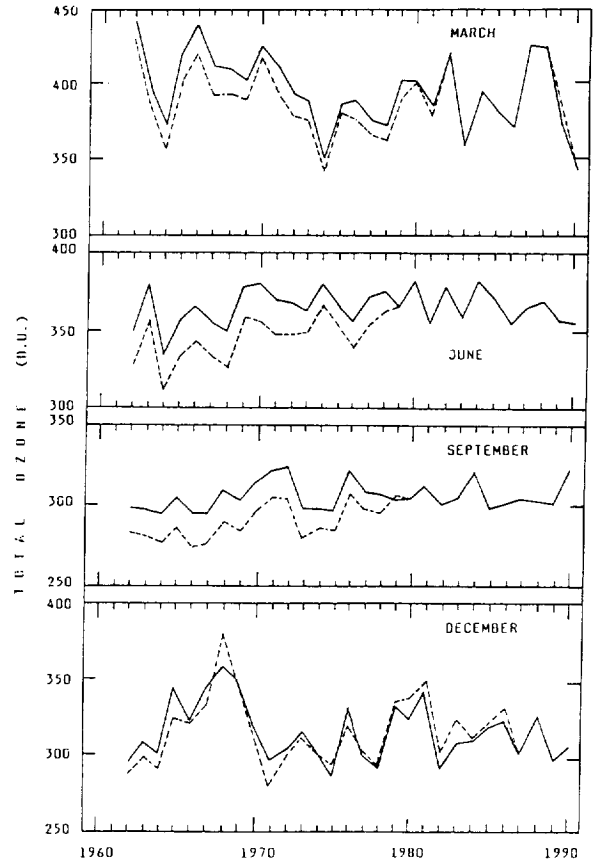

Fig. 1. Monthly averages of recalculated (full line) and original (dashed line) total ozone, Hradec Kralove, 1962-1990.

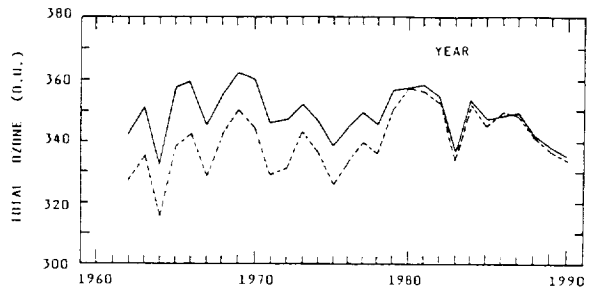

Fig. 2. Yearly averages of recalculated (full line) and original (dashed line) total ozone, Hradec Kralove, 1962-1990.

4. RESULTS AND CONCLUSIONS

The main results of homogenization are demonstrated in Figure 1 and Figure 2 and in Table 2. The figures show the monthly averages of original and recalculated total ozone in spring (March), summer (June), autumn (September), winter (December) and the yearly averages in individual years. It is evident from the graphs that the original data published by WODC in the past are significantly different from those recalculated in the period 1962-1979, except for the winter months. After readjustment and the first intercomparison of the spectrophotometer No.74 at Potsdam in June 1979 accuracy of measuring increased evidently at Hradec Kralove. This conclusion is demonstrated by the differences between original and recalculated monthly and yearly averages of total ozone given in Table 2 too.

The highest differences between original and recalculated values appear in the months April to October of the period 1962-1979. In the months November to February the differences are lower because of sub-

Table 2. Original minus recalculated monthly and yearly averages of total ozone (D.U.), Hradec Kralove, 1962-1990.

	MONTH												
YEAR	J	F	M	A	M	J	J	A	S	O	N	D	Year
1962	-24	-12	-15	-21	-23	-21	-24	-20	-17	-13	+1	-8	-15
1963	-11	-6	-14	-20	-22	-25	-19	-21	-19	-12	-7	-10	-16
1964	-4	-16	-18	-17	-22	-22	-20	-20	-20	-20	-10	-10	-17
1965	-11	-13	-19	-22	-23	-25	-26	-23	-20	-15	-13	-19	-19
1966	-6	-14	-19	-17	-24	-24	-25	-24	-22	-13	-11	-2	-17
1967	-7	-4	-20	-23	-25	-24	-25	-23	-21	-17	-4	-10	-17
1968	+23	-13	-17	-18	-25	-24	-26	-26	-22	-17	-8	+19	-13
1969	+15	+11	-14	-16	-25	-21	-22	-24	-20	-12	-8	-6	-12
1970	-5	-20	-8	-17	-19	-25	-24	-22	-21	-16	-13	-8	-16
1971	-8	-9	-19	-22	-17	-24	-21	-21	-18	-16	-14	-18	-17
1972	-1	-9	-16	-18	-19	-23	-25	-22	-22	-15	-10	-4	-16
1973	0	+5	-15	+5	-16	-16	-19	-18	-19	-18	-3	-3	-9
1974	+6	+2	-10	-16	-15	-16	-16	-17	-13	-16	-11	-3	-10
1975	-11	-21	-7	-18	-19	-23	-14	-16	-13	-12	+2	+7	-12
1976	+4	-1	-14	-17	-16	-18	-16	-18	-13	-9	0	-12	-11
1977	-2	-7	-10	-12	-18	-19	-18	-14	-13	-8	-5	+2	-10
1978	+8	+1	-10	-12	-14	-15	-17	-18	-13	-11	-8	0	-9
1979	-1	-16	-12	-14	-15	-1	+1	-1	+1	0	-3	+2	-5
1980	+3	-5	-1	+3	-1	0	+1	+3	-3	0	-5	+14	0
1981	+8	+10	-6	-4	0	-1	+3	+1	0	-3	+2	+6	+2
1982	+13	-2	-2	-2	-3	-1	-1	-2	-1	-1	-1	+8	+2
1983	+6	+1	+2	-1	+2	0	-1	0	+1	0	+2	+15	+2
1984	+3	+17	0	-1	-1	-4	-1	-2	-1	-1	+5	+1	+1
1985	+5	+6	0	0	+2	+1	-1	+1	+1	-1	+9	+3	+2
1986	-4	+2	-2	-1	0	0	-3	-1	-1	-1	+6	+4	-1
1987	+8	+6	+2	-1	-1	-1	-2	-2	-2	o	+3	-1	+1
1988	+4	+5	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	0
1989	-1	-1	-3	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
1990	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
MEAN													
62-90	0	-4	-9	-10	-12	-13	-13	-12	-11	-9	-4	-1	-8
62-79	-2	-8	-14	-16	-19	-20	-20	-19	-17	-13	-7	-5	-13
80-90	+4	+4	-1	-1	0	-1	-1	0	-1	-1	+2	-4	+1

sequent preference of measurements on the wavelength pair CD which compensated changes due to corrections of the R-N Tables. In the years 1980-1990 the differences are generally small as a result of periodical corrections of the R-N Tables based on regular standard lamp tests of the instrument performed since 1980.

The analysis of the results of homogenization showed that accuracy of measuring of total ozone was fairly good at Hradec Kralove in the period 1980-1990 when technical condition of the spectrophotometer No.74 was stable. But significant differences were found in the years 1962-1979 reaching 10-19 D.U. (3.0-5.5%) for yearly averages and even 26 D.U. (over 7,0%) for monthly averages in the summer-season. Such differences highly exceed accuracy of measuring with the Dobson spectrophotometer and can significantly influence reliability of the data base and namely character of trends. Due to this fact the recalculated total ozone data were published separately [Vanicek,1991] again. In this way the data were made generally available for studies concerning variation of atmospheric ozone over Central Europe. The results given above evidently support the requirements for re-evaluation of historical total ozone data sets of the GOOS's stations as an important step for improvement of quality of long-term monitoring of the ozone layer.

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